# SECTION I

# INTRODUCTION

# 1.0 Introduction

## 1.10 Purpose

This report was prepared in response to Section 114(c) of Public Law 95-604 dated November 8, 1978 (USC78). This Section of the Law stipulates that, "Not later than January 1, 1980, the Administrator, in consultation with the Commission, shall provide to the Congress a report which identifies the location and potential health, safety, and environmental hazards of uranium mine wastes together with recommendations, if any, for a program to eliminate these hazards." The purpose of this report is to comply fully with this request, as accurately and completely as available information will permit.

### 1.1.1 Contents

This volume has seven major sections. The content of each section is described generally below:

Section 1: Brief reviews of predicted future uranium production requirements; descriptions of methods of extracting uranium from the earth; and presently enforced standards and regulations governing uranium mining.

Section 2: A description of the active and inactive uranium mine inventory with a discussion of its limitations. The actual mine listings are presented in Appendixes E and F.

Section 3: A comprehensive discussion of potential sources of radioactive and stable contaminants to the environment and man from uranium mining operations. Annual release rates of contaminants from the identified sources computed on a generic basis.

Section 4: A description of model underground, surface, and in situ leach mines with operational parameters and source terms. Both active and inactive model underground and surface mines are described.

Section 5: A brief and general discussion of the environment that exists about uranium mines, including vegetation, wildlife, domestic animals, and human populations. The potential atmospheric and aquatic pathways of contaminants from the mines to man are also defined.

Section 6: Computation of individual and population dose equivalents and potential health effects from mine wastes and effluents based on the source terms developed in Section 3, the model mines defined in Section 4, and the pathways described in Section 5. A qualitative description of the environmental effects based on site visits is also presented.

Section 7: A brief summary of the report followed by the conclusions and recommendations.

## 1.2 Uranium Ore Production and Future Uranium Needs

### 1.2.1 Past Production

Table 1.1 lists the quantities of ore mined and uranium ($U_3O_8$) produced in the various uranium mining states between 1948 and January 1, 1979. Two states, New Mexico and Wyoming, have been the source of about 64 percent of the uranium mined in the United States. The Colorado Plateau, which includes parts of New Mexico, Arizona, Colorado, and Utah (see Figure 1.1), has been the largest source area of mined uranium, accounting for about 70 percent of the $U_3O_8$ production through 1976 (ST78). During this same period, the Gas Hills and the Shirley and Powder River Basins of Wyoming produced about 22 percent of the total $U_3O_8$ (ST78).

To produce 302,370 MT of $U_3O_8$ required the mining of 145,811,000 MT of uranium ore during the 31-year period from 1948 to 1979(DOE79). The average grade of ore, reported as percent of $U_3O_8$, was 0.208 percent during this period.

### 1.2.2 Projected Needs for Uranium

The expected growth in the use of nuclear energy for the production of electric power in the United States during the remainder of this century will require an expansion of the uranium mining industry. However, the magnitude of this expansion is difficult to estimate, because the forecasts that predict the growth of the nuclear power industry differ considerably (AEC74, ERDA75, EPA76, NRC76, NUS76, Cu77, He77, NEP77, EW78, Ni78, and St78). However, all forecasts predict a continued growth of the industry. Expansion of the uranium mining industry will be influenced also by decisions regarding fuel reprocessing and commercial utilization of breeder reactors.

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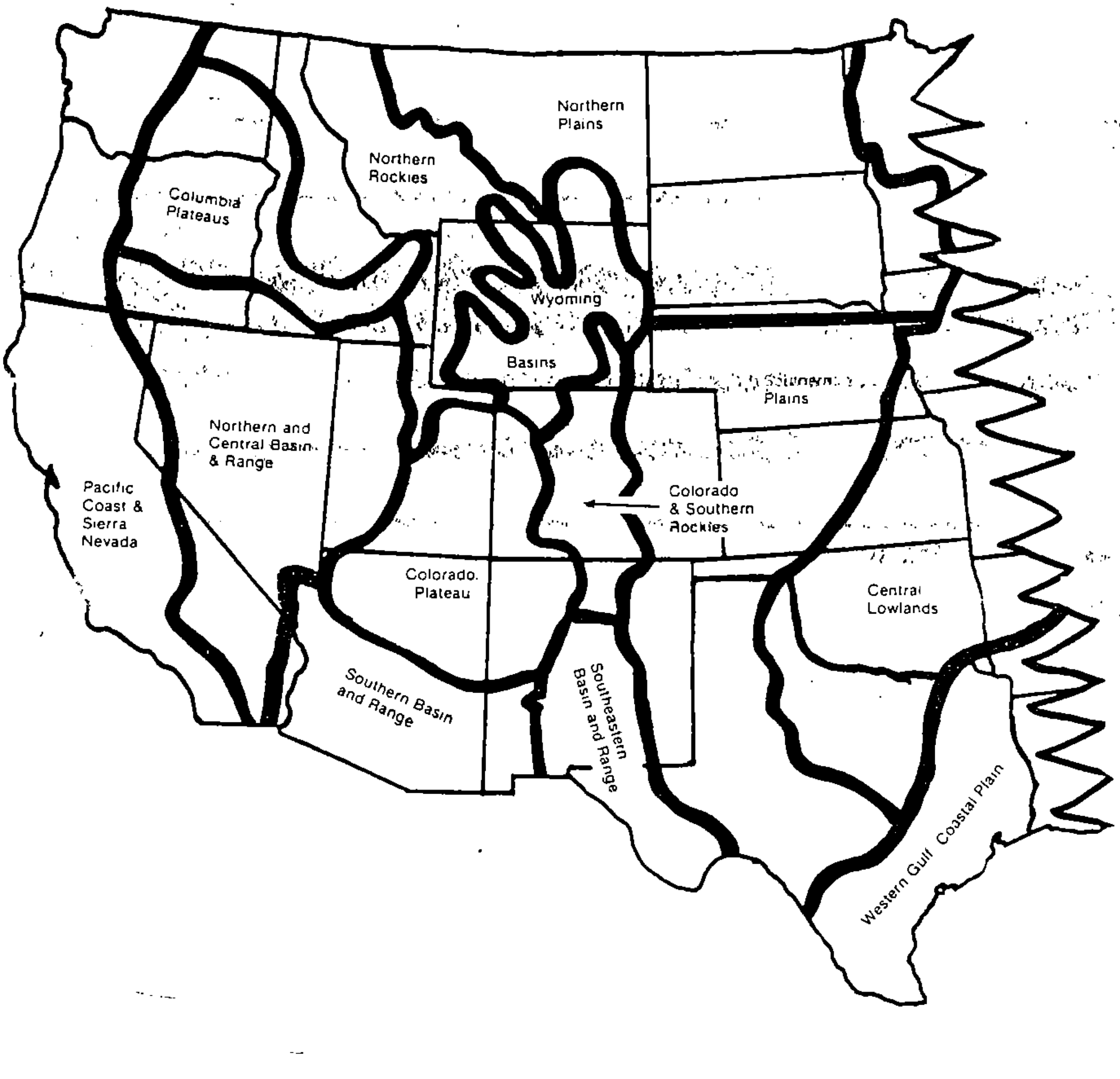


Figure 1.1 Uranium mining regions in the western United States

Table 1.2 gives examples of four typical forecasts. The Nuclear Regulatory Commission's (NRC) projected annual nuclear capacity is far below former predictions. This lower projection, which is in line with the administration's National Energy Plan (NEP77), is believed to be more realistic in view of recent drops in demand for electricity, labor problems, equipment delays, litigations initiated by environmental groups, the absence of a publicly accepted waste disposal program, and concern over nuclear proliferation. The Department of Energy predicts that 293,120 MT of $U_3O_8$ will be required to provide nuclear generating capacity through 1990 (DOE79). This assumes no uranium or plutonium recycling.

Table 1.3, which gives domestic uranium reserves by state, shows that the reserves are near the areas already mined. Figure 1.2 shows the distribution of \$50 ore reserves by state, and Fig. 1.3 shows reserves by resource region (see Fig. 1.1 for region locations). Future major mining activities probably will be in the same general areas that have already been mined. To obtain the 834,600 MT of \$50 $U_3O_8$ reserves will require mining about 1.14 x $10^9$ MT of ore with an average grade of 0.073 percent $U_3O_8$.

## 1.3 Overview of Uranium Mining Operations

### 1.3.1 General

The two major uranium mining methods used in the United States are underground mining and surface (open pit) mining. These two methods accounted for more than 98 percent of the uranium mined in the United States in 1971 (AEC74). This has decreased only slightly to about 93 percent in 1978 (DOE79). However, various types of solution mining are currently being tested and probably will be employed commercially more frequently.

Table 1.4 shows the current production capacities of $U_3O_8$ for the various mining methods. Although underground mines are far more numerous than surface mines, production by the two methods is nearly equal. This is because surface mines have a much larger capacity. During 1978, 305 underground mines accounted for about 46 percent (8,350 MT) of the $U_3O_8$ production while 63 surface mines produced about 47 percent (8,710 MT) of the $U_3O_8$. In situ leaching, heap leaching, mine water extraction, and other alternative methods accounted for the remaining 7 percent (1,270 MT).

Table 1.2 Projected annual nuclear capacity (GWe) in the U.S.

| Source | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|
| ERDA (ERDA75) | 71-92 | 160-245 | 285-470 | 445-790 | 625-1250 |
| USEPA (EPA76) | 80 | 188 | 350 | 578 | 820 |
| Electric World (EW78) | 92 | 160 | 194 | 237 | --- |
| NRC (NRC79)[a] | 61 | 127 | 195 | 280 | 380 |

[a] Schedule assumed for this document.

Note.--The actual nuclear capacity realized in 1977 was 49 GWe.

Table 1.3 Domestic uranium reserves by state as of January 1, 1979

| State | Ore, MT | Ore Grade, % $U_3O_8$ | $U_3O_8$, MT | % Total $U_3O_8$ |
|---|---|---|---|---|
| New Mexico | 482,200,000 | 0.09 | 434,000 | 52 |
| Wyoming | 431,300,000 | 0.06 | 258,800 | 31 |
| Texas | 83,400,000 | 0.05 | 41,700 | 5 |
| Arizona, Colorado, & Utah | 107,300,000 | 0.07 | 75,100 | 9 |
| Others[a] | 35,700,000 | 0.07 | 25,000 | 3 |
| Total | 1,139,900,000 | 0.073[b] | 834,600 | 100 |

[a]Includes Alaska, California, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota and Washington.

[b]Weighted average.

Note.--The uranium reserves in this table include ore from which $U_3O_8$ can be obtained at a forward cost of $50 per pound or less. Costs do not include profits or cost of money.

Source: DOE79.

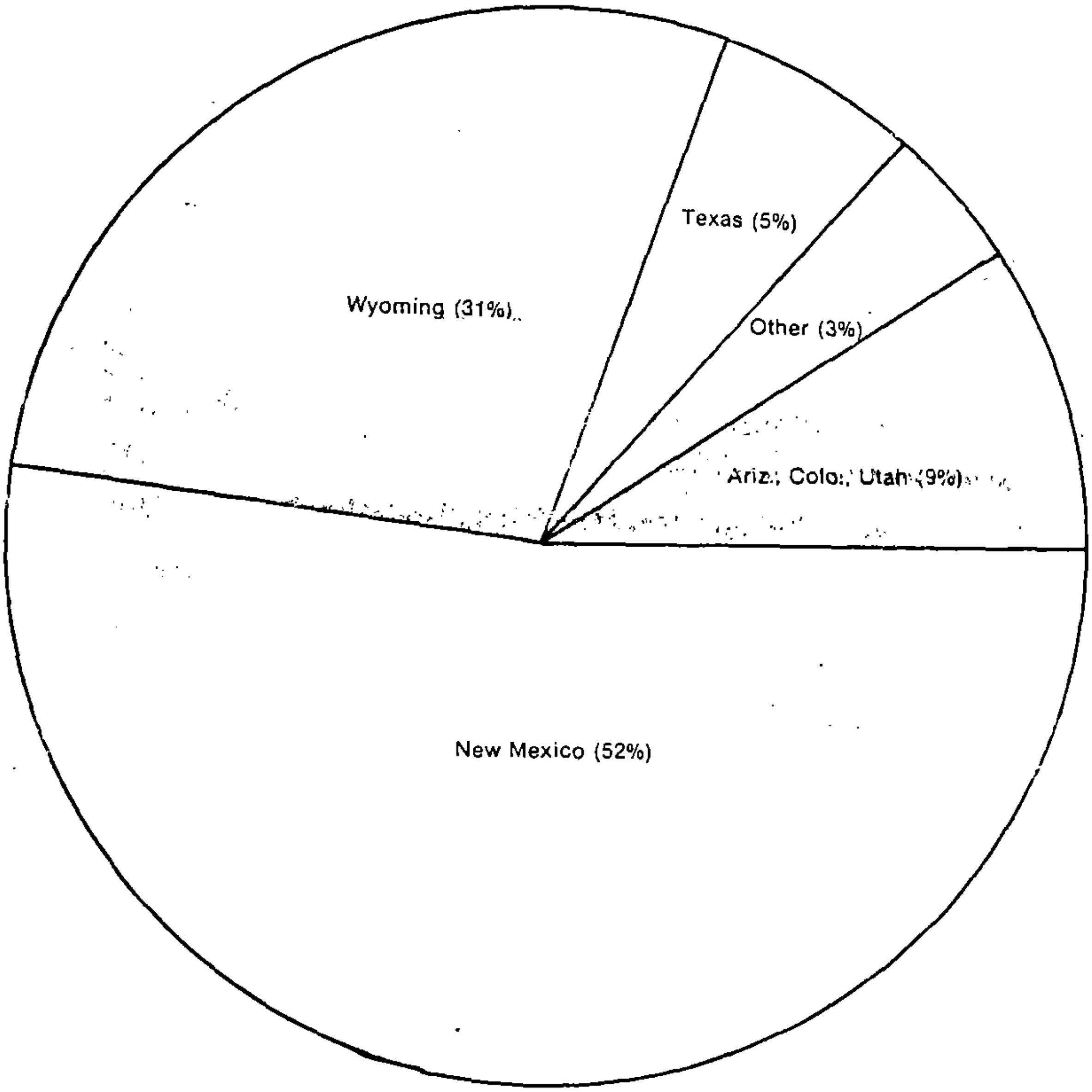


Figure 1.2. The percent of \$50 $U_3O_8$ reserves located in the principal mining states (DOE-79).

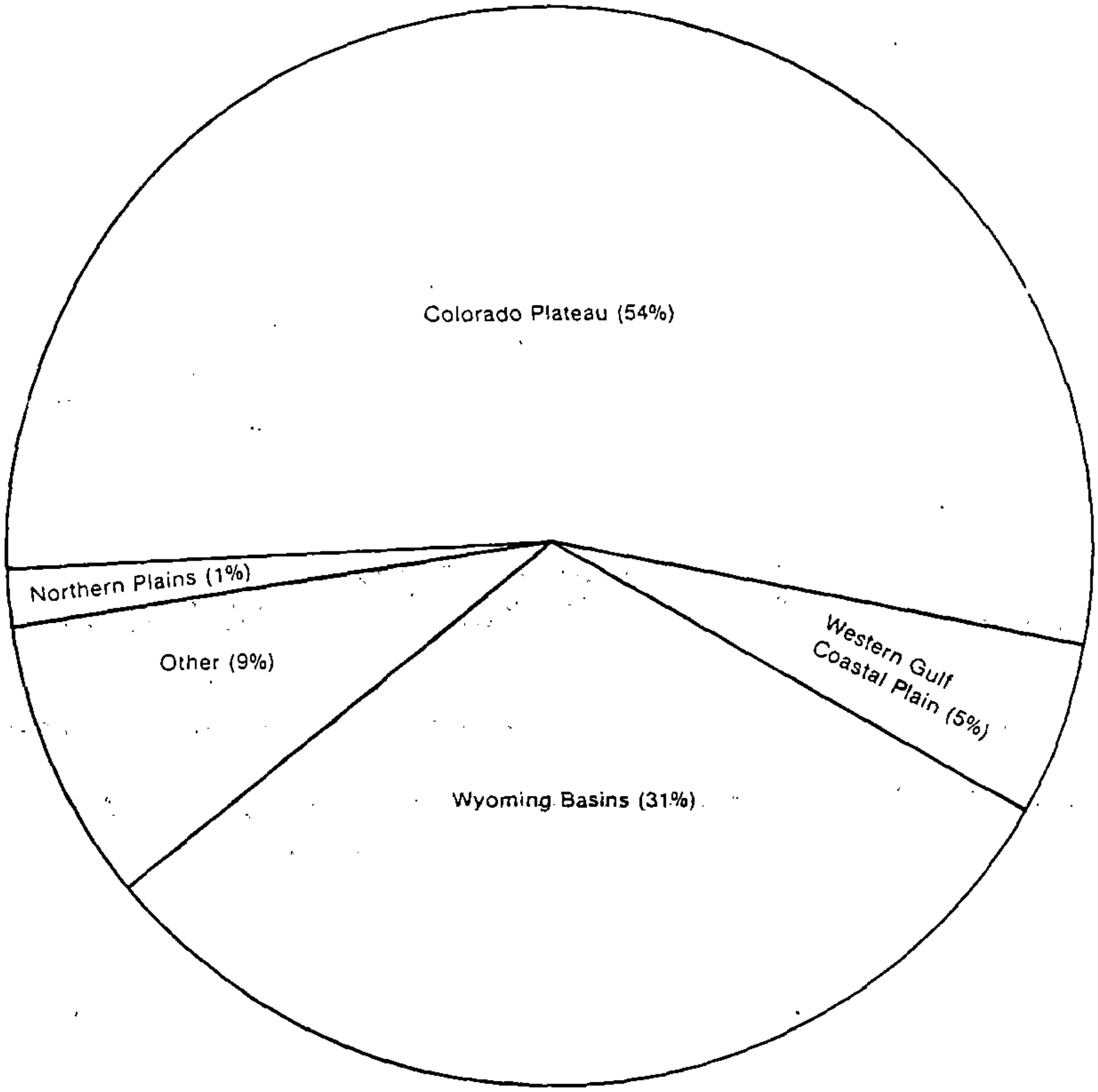


Figure 1.3 The percent of \$50 $U_3O_8$ reserves located in the various mining regions (DOE 79)

Table 1.4 Quantities of $U_3O_8$ produced in 1978 by the various mining methods

| Mining Method | MT of $U_3O_8$ | Percent[b] |
|---|---|---|
| Underground Mines (305)[a] | 8350 | 46 |
| Surface Mines (63) | 8710 | 47 |
| Other (23): In situ leaching, heap leaching, & mine water | 1270 | 7 |
| Total | 18,330 | 100 |

[a] The number of mines or sites are given in parentheses.

[b] Rounded to total 100 percent.

Source: DOE79.

Table 1.5 Predicted methods of mining ore reserves

| Mining Method | MT of $U_3O_8$ | Percent |
|---|---|---|
| Underground Mining | 547,000 | 66 |
| Surface Mining | 260,400 | 31 |
| Other: In situ leaching, heap leaching, & mine water | 27,200 | 3 |
| Total | 834,600 | |

Note.--These are reserves of the $50 per pound $U_3O_8$ or less cost category.

Source: DOE79.

Although some mines produced much more than others, one can compute a rough estimate of the average capacity of underground and surface mines as follows. The average grades of ore removed from underground and surface mines in 1978 were reported to be 0.155 percent and 0.120 percent $U_3O_8$, respectively (DOE79). Dividing the annual $U_3O_8$ productions (Table 1.4) of the two mining methods by their respective grades indicates that the 305 underground mines accounted for 5,387,100 MT of ore while 7,258,300 MT were removed from the 63 surface mines. Hence, the average ore production capacities of underground and surface mines are about $1.8 \times 10^4$ MT and $1.2 \times 10^5$ MT, respectively. From this assessment, the average ore capacity of a surface mine is about seven times that of an underground mine.

The trend during the past few years of an increasing percentage of $U_3O_8$ being mined underground will continue, because shallow deposits of high grade ore have tended to be surface mined first. Table 1.5, which displays the distribution of \$50 reserves by mining method, shows the continued increase in the proportion of $U_3O_8$ mined by the underground method. By the Department of Energy predictions, future production from underground mines will more than double that from surface mines. The NRC predicts $U_3O_8$ production by in situ leaching to peak in 1990 at about 4000 MT/yr and total 76,000 MT by the year 2000 (NRC79). If this prediction is realized, this resource will undoubtedly draw from those assigned to underground and surface mining in Table 1.5. The production of $U_3O_8$ by heap leaching and mine water extraction is predicted to be relatively small.

It is very difficult to predict how much $U_3O_8$ will be produced as a by-product from other mineral mines, but by-product production should increase total $U_3O_8$ production during the next 20 years. Approximately 180 MT of $U_3O_8$ are currently recovered each year from the phosphoric acid production at wet phosphate plants. The NRC predicts that this will increase to 1800 MT/yr by 1985 and possibly to 7000 MT/yr by the year 2000 (NRC79). If planned leaching facilities are actually built at copper waste dumps at Yerington, Nevada; Butte, Montana; and Twin Buttes, Arizona, to supplement the operating facility at Bingham Canyon, Utah, recovery of $U_3O_8$ from these operations could reach 900 MT/yr (NRC78). Hence, by-product $U_3O_8$ production could conceivably account for about eight percent of the required annual $U_3O_8$ production by the year 2000.

Although the depth of the ore deposit is the fundamental consideration in selecting the mining method to be applied to a particular ore body, the size and grade of the deposit are also important factors. The shape of the deposit, the overburden rock strength, environmental considerations, and other factors may also influence the selection. Surface mining is generally used for relatively shallow deposits; rarely for those below 400 feet (St78). However, under some conditions, it may be cheaper to mine a small, shallow, high-grade ore deposit by underground methods; whereas, a larger low-grade deposit at a greater depth may be cheaper to mine by surface mining. Because productivity is greater by surface mining, it is generally preferred when conditions are favorable. Other factors must be examined when considering the use of in situ leaching (see Section 1.3.4).

1.3.2 Surface Mining

The use of surface (open pit) mining methods is most prevalent in the Gas Hills Region and the Shirley and Powder River Basins in Wyoming, the Laguna District of New Mexico, the coastal plains in south Texas, and some areas of Colorado and Utah (St78). Fig. 1.4 illustrates a typical open pit mine.

In surface mining, an open pit is dug to expose the uranium deposits. After the topsoil is removed and stockpiled nearby, the overburden is removed by the method best suited to the nature of the rock. If the rock is easily crumbled, it is removed by tractor-mounted ripper bars, bulldozers, shovels, or pushload scrapers; if it is not, blasting and drilling are required. The broken rock is then trucked to a nearby waste dump. Occasionally, dikes and ditches are constructed around these waste piles to collect runoff and divert it to sedimentation ponds. Overall, an area of a hundred or more acres may be covered by stored overburden wastes (AEC74).

As mining progresses, the overburden is used as it is removed to backfill mined out areas of the pit. When an area is completely backfilled, it is graded to conform to the surrounding topography and to restore the natural drainage patterns. The area is then covered with topsoil and seeded to blend with the natural terrain. Most of the older surface mines were not backfilled (see Section 3.7.1), and neither are many of the currently active surface mines.

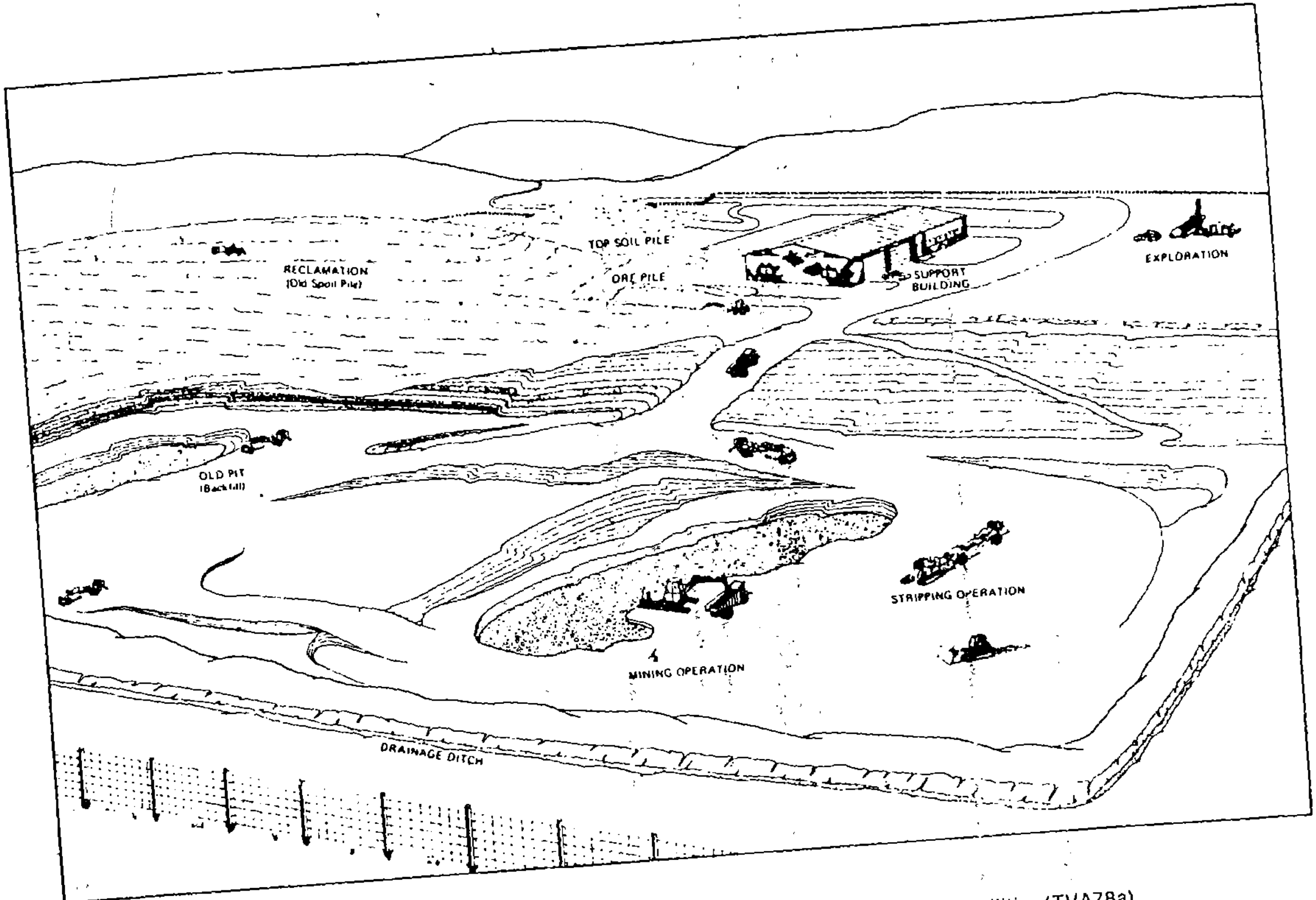


Figure 1.4 Artist's conception of open pit mining operation and support facilities (TVA78a)

Contact with the ore zone is determined by gamma and x-ray detection instruments, usually Geiger-Muller counters that have been calibrated to indicate the uranium content of the rock. Since uranium is usually in sandstone formations, the ore is easily removed. Large backhoes and front-end loaders are often used to remove ore that has been loosened with tractor-mounted rippers. Large ore trucks carry the ore from the pit to stockpiles at the mine or the mill. Uranium ore is usually stockpiled by grade, e.g., high-grade, average-grade, low-grade. Sub-ore grade rock is also usually stored separately in piles. This is rock that contains $U_3O_8$ at a concentration below what the mill will now accept, but which might later be worth recovering.

Drifts (small tunnels) are sometimes driven into the pit wall to recover small, narrow ore pods. The drifts are generally short, sometimes less than 30 meters. The mining techniques in these drifts are like those used in underground mining (see Section 1.3.3).

Surface mining requires a network of roads from and around the pit area and to the mill. Heavy vehicles operating on these roads, and the digging itself, produce a certain amount of rock and ore-dust. However, the dust can be kept down by routinely sprinkling the roads with water or using other dust suppressants. Treated water from the sedimentation ponds is sometimes used for this purpose.

The ratio of overburden to the ore produced in an open pit mine can vary from 10:1 to as high as 80:1 (St78). One source has estimated the average ratio as 30:1 (Le77). A recent study of eight large open pit uranium mines reported a ratio of 77 (± 36) to 1 (Ni79). Since the latter study did not consider the many smaller surface mines where the overburden to ore ratio is likely to be smaller than 77 to 1, this report will assume an average ratio of 50:1. Considering that the average ore capacity of an open pit mine is approximately 1.2 x $10^5$ MT/yr (see Section 1.3.1), about 6 x $10^6$ MT of overburden must be removed annually and initially stored on the surface until reclamation procedures can be initiated.

Since most uranium deposits lie below the water table, groundwater must be prevented from flooding the mining area. One method is to surround the pit with several large capacity wells to lower the water table near the pit. This water is discharged directly into the natural surface drainage system, in accordance with the National Pollutant Discharge Elimination System (NPDES) discharge permit issued to the mining company. Water that does collect in the pit (mine sump water) is pumped to a sedimentation pond for solids removal and, if necessary, for subsequent treatment prior to discharge into the natural drainage system. Another mine dewatering procedure often used consists of ditches dug along the interior perimeter of the pit floor to channel the water to sumps located at the lowest levels of the pit floor. Water that collects in the sumps is pumped to one or more sedimentation basins for solids removal, possible treatment, and final discharge into the existing natural drainage system in accordance with water quality standards specified in the NPDES permit. The rates at which mines are dewatered range from 0.28 $m^3$/min to 288 $m^3$/min (AEC74, TVA78a, NRC77a, NRC77b).

Barium chloride, to coprecipitate radium, and a flocculent (an agent causing aggregate formation) to remove other contaminants are usually added to pond water before it is discharged. Water with a high concentration of dissolved uranium is often run through ion exchange columns, and the resin regenerant solution containing the uranium is sent to the mill for processing. The precipitated sludge that collects on the pond bottom consists primarily of ferric and calcium hydroxides, calcium sulfate, and barium sulfate with coprecipitated radium. At some sites, this precipitated sludge is transferred to the mill tailings pond at the end of the mining operation.

A small amount of uncontrolled seepage may occur through the bottom of sedimentation ponds and, depending upon soil permeability and direction of flow, may enter the water table. For example, the seepage rate through the bottoms of two settling ponds totaling 4.9 hectares at one site was less than 0.57 $m^3$/min (NRC77a). In addition, seepage can be reduced by lining the ponds (well-compacted bentonite clay is sometimes used for this purpose) and by the sludge that accumulates on the pond bottom.

During active surface mining operations, a total of several thousand hectares of land area will be disturbed (St78, Th79). When all uranium has been mined and the operation is completed, a pit remains. The walls of the pit may be contoured and allowed to fill with water, creating a small man-made lake.

### 1.3.3 Underground Mining

Underground mining is much less disruptive to the surface terrain than open pit mining. The surface affected generally involves less than 41 hectares, but the mine may extend laterally underground for more than a mile and at several depths. Figure 1.5 illustrates a typical large, contemporary underground mine.

In underground mining, access to the ore body is gained through one or more vertical shafts, generally sunk to a slightly greater depth than the ore body, or through inclines, declines, or adits, all cut through waste rock. The waste rock is removed to a spoils area that may be, but usually is not, surrounded by a ditch to contain runoff, as discussed above.

The sizes of the accesses vary considerably. The vertical haulage shaft may vary from less than 8 feet in diameter, sufficient to accommodate one small ore skip (a large bucket), to a diameter of 20 feet, which will accommodate dual ore skips as well as a man and material skip. In some cases, the near horizontal accesses are sufficiently large to allow passage of large diesel-powered vehicles.

Underground mines are developed in a way that minimizes the removal of waste rock, resulting in much smaller spoil storage piles than those at surface mines. It is estimated that the ore to waste rock ratio generally ranges from 20:1 to 1:1 (ACE74, Th79). At seven presently active mines, the ore to waste rock ratio ranges from 1.5:1 to 16:1 with an average ratio of 9.1:1 (Ja80). Using the average ratio and the average annual ore capacity of an underground mine (see Section 1.3.1), each year the average underground mine will produce about $2.0 \times 10^3$ MT of waste rock that is removed and stored on the surface. Initially all waste rock is transported to the surface, but,

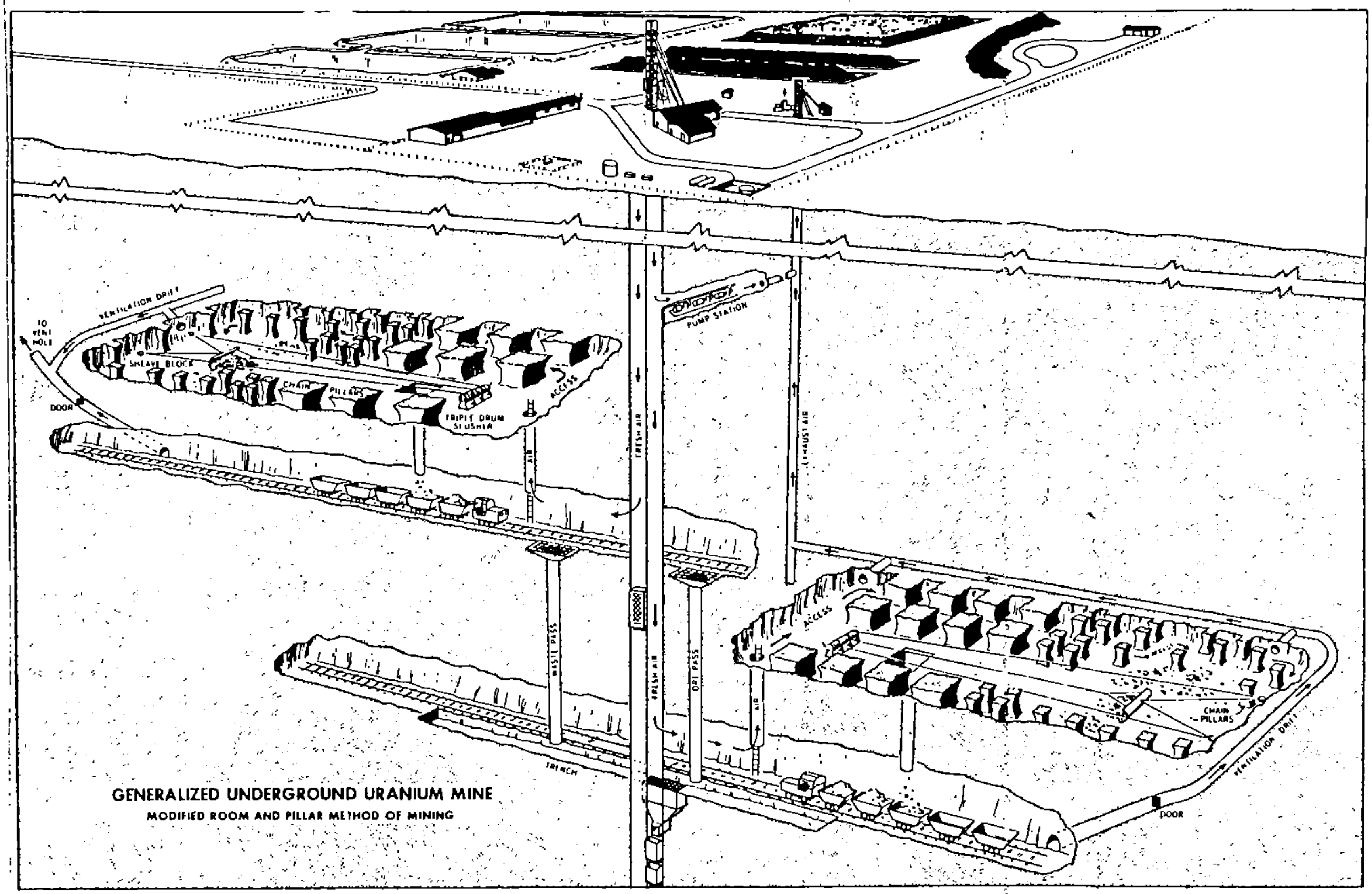


Figure 1.5 Generalized underground mine showing modified room and pillar method of mining (TVA78b)

as mining progresses, it is sometimes transported to mined-out areas of the mine and retained beneath the surface. This practice may diminish as lower grade sub-ore becomes more economical to mill. Since waste rock may contain sub-ore, some waste rock will likely be kept available for milling.

Ore deposits, outlined by development drilling, are followed as closely as possible. When ore lies in narrow, long deposits, drifts are cut through the ore body and raises or stopes are driven from the drift to reach small ore pods. Crosscuts are driven from the haulage drifts when necessary to reach nearby deposits. Large area deposits are commonly mined by the "room and pillar" method. This involves mining out blocks of ore while leaving adjacent pillars of ore or waste as support for the roof. The size of the rooms depends on the roof condition. The roof is usually strengthened by bolts, wire mesh, timbersets, and steel arches. When an area is completely mined, the ore pillars are removed in a systematic sequence that allows safe retreat.

Ore is usually broken by drilling and blasting. The broken ore is removed and transferred to mine rail cars. The ore is then carried by rail cars or wheeled vehicles either directly to the surface or to a skip at the bottom of the haulage shaft and lifted to the surface. Haulage in large area mines is often accomplished by large diesel-powered loaders, haulers, and trucks. When the ore is sufficiently soft, it may be removed with continuous mining machines instead of drilling and blasting techniques; however, most ore bodies are too small and irregular to mine economically this way.

Ventilating systems are required in underground uranium mines to remove blasting fumes and radon-222 (Rn-222) that emanates from the ore and mine water and to control temperature. Fresh air is usually forced down the main haulage shaft and along the main haulage drifts to the working areas. The mine air is exhausted through ventilation shafts to the surface. The ventilation air is diverted from inactive areas of the mine to reduce air contamination. Inactive areas are usually sealed with airtight bulkheads to prevent radon gas in those areas from circulating. The ventilation rate should be sufficient to maintain the radon daughter concentration of the mine air at, or below, levels that meet federal and state occupational exposure standards. The rate will vary depending upon mine size (volume), grade of exposed ore, size of the active working areas, rock characteristics (diffusion rate of Rn-222), effectiveness of bulkhead partitions, atmospheric pressure, and other factors. Ventilation rates in active mines vary from a few hundred $m^3$/min to over a hundred thousand $m^3$/min. For example, the ventilation rates for seven uranium mines in the Grants, New Mexico area ranged from $4.4 \times 10^3$ to $1.1 \times 10^4$ $m^3$/min, with an average of $7.4 \times 10^3$ $m^3$/min (Ja79).

Because ore bodies often lie in or beneath major aquifers, dewatering operations similar to those practiced in surface mining are required. These operations commence during the initial shaft-sinking process and may continue throughout the working life of the mine. Water is pumped from wells that are driven into the water-bearing strata near the mining operation and discharged either directly into the natural surface drainage system, in accordance with an NPDES permit, or to settling ponds. Water that collects in the mine is diverted to sumps and pumped to a settling pond. The impounded mine water is treated similarly to that described above at surface mines (see Section 1.3.2). The discharge of water from these ponds is in accordance with water quality standards specified in the NPDES permit. (Note.--About one-half of the active New Mexico mine discharges have NPDES permits that are presently under adjudication and, therefore, are not necessarily in accord with discharge limits [Pe79a].)

### 1.3.4 In Situ Leaching

In situ leaching has less adverse impact on the environment than conventional uranium mining and milling methods. It also may permit economical recovery of currently unrecoverable low-grade uranium deposits (NRC78). Though in situ leach mining currently produces only a small amount of the annual U.S. output of $U_3O_8$, variations of this technique are being widely tested for uranium extraction and have potential for becoming commercially significant (La78, NRC78, TVA78b, Ka78). Table 1.6 lists in situ leaching operations for uranium as of January 1, 1978. The operations are concentrated on the coastal plain of southwest Texas and in the Wyoming basin regions. Most commercial sized operations are in southern Texas, where recent expansion is expected to increase the production of $U_3O_8$ by this technique to about 900 MT annually (TVA78b). Two Texas sites alone, Bruni and Lamprecht, are expected to produce annually 110 and 230 MT of $U_3O_8$, respectively (Wy77). A number of projects are currently testing the effectiveness of the in situ leaching technique. Though these studies usually last about 18 months to 3 years, some feasibility tests require up to 6 years before expanding to full or commercial scale operations (La78). Excellent reviews of this mining method are available (La78, Ka78).

Uranium extraction by in situ leaching probably will not be restricted to one or two geographical areas. Uranium deposits potentially suitable for mining by this method are prevalent in almost all of the established uranium mining areas in the United States. Uranium deposits are potential candidates for in situ mining if they meet the following criteria: (1) the ore deposit is located in a zone saturated with water; (2) the ore deposit lies above and preferably between geological layers impervious to water; (3) the deposit is adequately permeable to water; and (4) the uranium in the ore deposit is in a leachable state. Colorado and New Mexico already have in situ leaching activities at the pilot scale, and the mining industry has inquired about additional pilot-scale research and development sites in South Dakota, Arizona, Utah, and Montana (La78).

In the in situ leaching method, a leaching solution (lixiviant) is injected through wells into the uranium-bearing ore body. It forms chemical complexes with the uranium, which dissolves in the solution. Production wells bring the uranium-bearing solution to the surface where the uranium is extracted. The barren lixiviant can then be reconstituted and reused. To control groundwater flow, the production (pumped) well operates as a sump or pressure sink in the formation, which produces a flow of groundwater and lixiviant from the injection wells to the production well. Also, some of the barren lixiviant is not reinjected. This reduces the water level in the well field, allowing groundwater to migrate into the mining zone. This inflow prevents the flow of the lixiviant away from the field area.

Lixiviants for in situ mining contain salts of anions (negatively charged chemical groups), such as sulfate, carbonate, bicarbonate, and ammonium, that form stable aqueous complexes with hexavalent (positively

Table 1.6 Summary of current in situ leaching operations as of January 1, 1978

| Name | Location | Well[a] Pattern | Scale of[b] Operation | Flow Rate[c] ($m^3$/min) |
|---|---|---|---|---|
| Sundance Project | Crook County, WY | 5-SP | RD-PS | ND[d] |
| Red Desert Site I | Sweetwater County, WY | 5-SP | RD-I | ND |
| Red Desert Site II | Sweetwater County, WY | 5-SP | RD-PS | ND |
| Charley Site | Johnson County, WY | 5-SP | RD | ND |
| Highland Site | Converse County, WY | 7-SP | RD-C | 4.54 |
| Double Eagle Site | Carbon County, WY | 5-SP | RD | ND |
| North Rolling Pin Site | Campbell County, WY | 5-SP | RD-I | ND |
| Collins Draw Site II | Campbell County, WY | 5-SP | RD | 0.38-0.57 |
| Bear Creek Site | Converse County, WY | 5-SP | RD-I | ND |
| Nine Mile Lake Site | Natrona County, WY | 5-SP | RD-PS | 0.38 |
| Red Desert Site | Sweetwater County, WY | 5-SP | PS | 0.38 |
| Irigaray Site | Johnson County, WY | ND | C | 6.06 |
| Site No. I | McKinley County, NM | 4-SP | PS-I | ND |
| Site No. 2 | Sandoval County, NM | 4-SP | PS-I | ND |
| Crownpoint Project | McKinley County, NM | 4-SP | RD | ND |

Table 1.6 Summary of current in situ leaching operations as of January 1, 1978 (continued)

| Name | Location | Well[(a)] Pattern | Scale of[(b)] Operation | Flow Rate[(c)] ($m^3$/min) |
|---|---|---|---|---|
| Grover Site | Weld County, CO | 5-SP | PS-C | 0.76 |
| Palangana Dome Site | Duval County, TX | ND[(d)] | C | ND |
| O'Hern Site | Duval County, TX | ND | C | ND |
| Bruni Site | Duval County, TX | ND | C | ND |
| Lamprecht Site | Bee County, TX | ND | C | 0.76 |
| Zamzow Site | Live Oak County, TX | ND | C | ND |
| Boots/Brown Site | Live Oak County, TX | ND | C | ND |
| Clay West Site | Live Oak County, TX | ND | C | ND |
| Burns Ranch Site | Live Oak County, TX | ND | C | ND |
| Moser Site | Live Oak County, TX | ND | C | ND |

(a) Well pattern: 5-SP indicates one or more 5-spot pattern(s), etc. See Figure 1.6.

(b) Given are past or present operations - planned future operations: RD-research and development, PS - pilot scale, C - commercial scale, I - presently inactive.

(c) Flow rate of leachate to processing plant in $m^3$/min.

(d) No data.

Source: La78; Du79.

charged in the +6 state) uranium. An oxidant, such as air, oxygen, hydrogen peroxide, sodium chlorate, sodium hypochlorite, or potassium permanganate, is added to oxidize the uranium to the hexavalent state. For example:

$$UO_2 + H_2O_2 + 2HCO^-_3 \rightarrow UO_2(CO_3)_2^= + 2H_2O$$

Unfortunately, there is no lixiviant specific for uranium. Consequently, other minerals commonly associated with uranium deposits, such as iron, selenium, vanadium, molybdenum, and arsenic, may also be dissolved. This tends to contaminate the leach solution and deplete the lixiviant. Lixiviant agents and their concentrations are selected to maximize uranium recovery and minimize undesirable secondary reactions. Acidic solutions (pH 2) are avoided because they are less selective. Neutral or basic lixiviants (pH 6-10), such as ammonium or sodium carbonate or bicarbonate, are often used.

Many variables affect the accumulation of trace elements in leaching solutions, particularly the chemical and physical nature of the host formation. Table 1.7 illustrates relative contaminant levels in the two lixiviant types in a laboratory experiment. Except for Ra-226, significantly greater trace element concentrations occur in the acid lixiviant; the total dissolved solids is about eight times higher than in the alkaline solution. Hence, it would be necessary to bleed much larger volumes of acidic lixiviant from the system prior to reinjection in order to maintain acceptable levels of these undesirable constituents. Large volumes of liquid wastes containing higher toxic metal concentrations are generally produced when acidic lixiviants are employed. Also, because calcium minerals are abundant in geologic strata and carbonate minerals are highly soluble in acid solutions, particularly calcium carbonate, large amounts of calcium accumulate in recirculated acid lixiviant, and they must be removed by a purification process prior to reinjection. However, acid lixiviants leach more rapidly than alkaline ones, yield higher uranium recoveries -- about 90 percent with sulfuric acid compared to 60 to 70 percent with a bicarbonate solution -- and generally extract less radium (Wy77).

The number of wells, their spacing, and their pattern depend upon the size and hydrologic characteristics of the formation. Figure 1.6 shows diagrams of some common well patterns. Several hundred injection wells with several recovery wells may be employed. Well spacing may vary from 10 to 60 m. In addition, a number of monitoring wells are driven a short distance from the well field to detect any excursion of lixiviant from the leach field. A commercial-size operation may require a well field area of 20 hectares or more (TVA78b).

The pregnant (containing uranium) leachate from the production wells is filtered through a sand filter to remove suspended particulates, then passed through a surge tank (storage reservoir) to ion-exchange resin beds that selectively remove the uranium complex. The uranium is washed from the resin beds, precipitated, filtered, dried (at most sites), and packaged.

Some processes of solution mining produce liquid and solid wastes. The volume of liquid wastes produced is much smaller, per weight of $U_3O_8$ produced, than that from the dewatering activities of conventional mining methods. There is also no waste rock. Residues obtained from drilling are a solid waste. Those that traverse the ore zone will contain some uranium ore. If calcium or sulfate control of the lixiviant is necessary, additional solid wastes are impounded in waste ponds under a liquid seal to minimize atmospheric dispersion. Precipitation compounds will also be produced as evaporation concentrates the impounded waste solutions.

Liquid waste streams include lixiviant, filter and resin washes, resin eluant bleed, and water used in cleaning the injection wells. The total production rate of these waste streams may vary between 0.19 to 0.38 $m^3$/min (Ka78, Wy77, TVA78b). At most sites, all liquid wastes flow to waste ponds and evaporate. Pond size depends on the flow rate of the wastes and the evaporation rate. The pond bottoms are usually lined with clay, asphalt, or a continuous plastic sheet to minimize the seepage rate, although some seepage may inadvertently occur. Deep-well injection is also used, principally in Texas, to dispose of liquid wastes from in situ leaching (Du79).

Table 1.7 Trace metal concentrations of recirculated acid and alkaline lixiviants

| Trace Metal | Concentrations, mg/ℓ: Acidic[a] | Alkaline[b] |
|---|---|---|
| Arsenic | <0.05 | <0.05 |
| Chromium | 0.15 | 0.07 |
| Cobalt | 0.2 | NR[c] |
| Copper | 1.0 | 0.04 |
| Iron | 25.4 | 0.6 |
| Lead | 0.7 | 0.2 |
| Manganese | 1.2 | NR |
| Molybdenum | NR | 0.9 |
| Nickel | 0.6 | 0.06 |
| Selenium | NR | 1.6 |
| Strontium | 3.7 | 1.5 |
| Vanadium | 1.0 | NR |
| Zinc | 4.3 | 0.1 |
| Zirconium | 3.3 | 0.9 |
| Radium-226[d] | 390 | 1750 |
| TDS[e] | 7.8 | 1.0 |

[a] Composition - 5 g/ℓ $H_2SO_4$ and 0.1 g/ℓ $NaClO_3$.
[b] Composition - 8 g/ℓ $NH_4HCO_3$ and 1 g/ℓ $H_2O_2$.
[c] NR - Not Reported.
[d] Units - pCi/ℓ.
[e] Total dissolved solids in grams.
Source: Ka78.

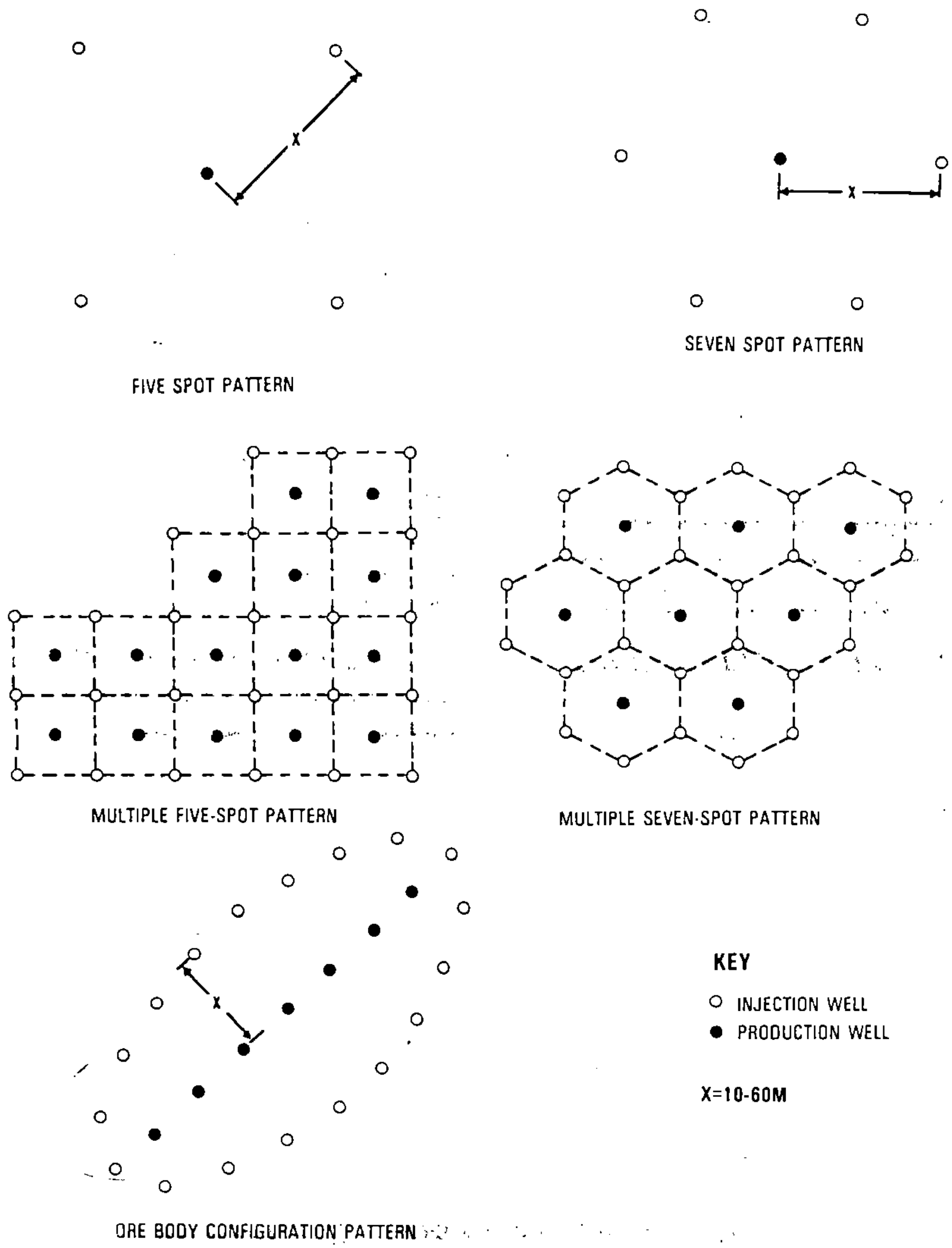


Figure 1.6 Diagrams of some common injection-recovery well patterns used in uranium in situ leach mining.

Atmospheric emissions from in situ leaching include Rn-222 that is vented mainly from the pregnant lixiviant surge tanks and particulate matter that may escape from the scrubbers (exhaust filters) of the yellowcake (uranium product) drying and packaging units. Radon-222 emanation from the waste ponds is probably negligible, since the sediment which contains the radium remains submerged and little Radon-222 will diffuse through the water and escape to the atmosphere.

When the mining operation is completed, the water volume of the leach zone will be restored to limits set by regulatory agencies. The primary method of aquifer restoration is flushing the zone with groundwater by pumping from the production wells and/or the injection wells. This process may produce up to 1.70 $m^3$/min additional liquid wastes that contain a high concentration of dissolved solids (NRC78). This contaminated water passes through an ion-exchange unit and then discharges to the waste ponds. The barren effluent can be further treated by desalination and reinjected to the formation. Also, a barium chloride solution can be injected into the leach zone to coprecipitate radium from the aquifer water prior to the groundwater sweeps.

### 1.3.5 Other Mining Methods

#### 1.3.5.1 Heap Leaching

Ore of a grade too low to be economically extracted in the mill operation is sometimes treated by heap leaching. In this process, the low grade ore is placed in large, rectangular, open-air piles on a specially prepared pad. To construct the heap-leach pad, the topsoil is first removed and the cleared area graded to a 2 percent to 3 percent slope. The graded area is then covered by a plastic sheet. Perforated plastic pipe is placed on the plastic parallel to the slope and covered with approximately 30 cm of clean, coarse gravel. A collecting trough is formed at the base of the slope and a berm surrounds the pile area.

When the ore is dumped on the pad, large solution reservoirs are formed on the top. Acidic or alkaline mine water is pumped into the reservoirs and percolates through the pile. The percolated water is collected in the trough and recirculated until the concentration of uranium in solution is sufficient to be economically extracted. The leaching process may require up to six months to recover approximately 80 percent of the uranium in the ore (NRC77a). The heap-leach pile at one mine contained an annual accumulation of approximately 360,000 MT of low-grade ore (NRC77a). The pile measured 300 m x 90 m x 7.6 m with solution reservoirs of 22 m x 90 m x 1.5 m.

After leaching operations are completed, the leached pile is neutralized with lime to a pH of about 7. The site is then contoured to blend with the surrounding terrain, covered with layers of subsoil and topsoil, and seeded to control wind and water erosion.

Because necessary information is unavailable and the contribution of heap leaching to the total uranium production is very minor and not expected to become significant (NRC79), an assessment of the environmental impact of heap-leached piles has not been conducted. However, the NRC has recently concluded that, although the hazard of tailings produced by heap leaching will be much less than the hazard of tailings at conventional uranium mills, the same tailings management and disposal criteria should possibly apply (NRC79).

### 1.3.5.2 Mine Water Recirculation

At several sites mine water is recirculated to leach "worked-out areas" of underground mines (Pe79b). In the early uranium mining years, ore with less than about 0.15 percent $U_3O_8$ was not mined. This grade is relatively high compared to present day markets. Consequently, significant quantities of uranium remain in these abandoned areas. Because the roofs of these areas collapsed during the initial mining retreat, this ore is difficult to retrieve by conventional methods. To recover a portion of this uranium, holes are drilled to the top of the collapsed zone and mine water is sprayed from these holes onto the shattered ore. Water for leaching may be sprayed from the mine floor if the abandoned area is accessible to the workers (Pe79a). The oxidized uranium (uranyl ion) is leached by the slightly alkaline mine water, which flows to collection sumps. The enriched water is pumped to a resin ion-exchange unit to extract the uranium, and then it is recycled.

After the available oxidized uranium has been leached, the process is discontinued for a few weeks to allow more uranium to oxidize. Mine water is then circulated again through the ore.

This process increases the recovery of uranium with minor effort and expense, but it contributes little to the total domestic uranium production (NRC79). In addition, the quality of the stored mine water used will be enhanced after passing through the resin ion-exchange unit. Hence, mine water recirculation has little impact on the environment. It was not assessed in this study.

1.3.5.3. Borehole Slurry Mining

Hydraulic borehole slurry mining is a recently proposed technique for extracting uranium ore (Ka78, St78). As the name suggests, this method uses pressurized water to loosen and combine with ore-bearing material to form a watery mixture known as 'slurry' that is transported from the borehole and then conventionally milled. This method could be applied to sandstone deposits at depths of 30 m to about 100 m. By present estimates, yellowcake from ore containing 0.06 percent $U_3O_8$ and mined at a 60 m depth by this method would cost $42 per pound (Ka78). This method presently is not as economical as the more conventional methods of uranium mining.

The process consists of drilling a 45-cm diameter hole to approximately 2 m below the uranium-bearing strata. A cutting jet assembly is positioned in the hole at the end of a rigid service column containing conduits for the pressurized water and slurry transport. The slurry pump is placed at the bottom of the hole. The underground mining operation is started with the jet set at the lowest position. The rotating jet cuts material through an arc of somewhat less than $360^0$ for a distance of up to 25 m, depending upon the design of the jet system. The segment of unmined ore acts to support the overlying strata. After the material is removed as a slurry, the jet is raised to the next level of ore and the process is repeated. After milling, the decanted water from the slurry is recycled for slurrying more ore. The tailings from the milling operation are used to backfill the borehole cavities and minimize subsidence.

A 15 m to 25 m radius borehole can be mined in an 8- to 24- hour period (Ka78). Large ore bodies might be mined by drilling, slurrying, processing, and backfilling in a systematic pattern that leaves ore in between boreholes for support. These areas could be mined in a second phase after the original boreholes are backfilled.

Borehole mining for uranium is currently only a proposed method with no pilot or commercial scale units in operation. Thus, the possible environmental impact from this process was not assessed in this study.

### 1.3.5.4. Uranium as a By-Product

The recovery of uranium as a by-product from other mineral mining and milling operations was discussed briefly in Section 1.3.1. Since recovery is basically from the milling operation, any environmental problem that might exist is associated with milling rather than mining. Therefore, it was not assessed in this study.

## 1.4 Current Applicable Standards and Regulations

### 1.4.1 Federal Regulations

Health, safety, and environmental hazards associated with uranium mining are regulated by Federal and State laws. This review focuses on laws and regulations applicable to mine operations. Nuclear Regulatory Commission regulations for milling operations apply to in situ leach extraction and are therefore included. Some laws and regulations on exploration rights also cover the environmental impact of mining operations and wastes.

Prior to the National Environmental Policy Act (NEPA) of 1969, there were few regulations protecting the environment of lands not controlled or owned by the Federal Government. Even with NEPA, much Federal authority on environmental problems was unused until recently. This Act established a national policy concerning the environment. Section 102(2) (C) states that every agency of the Federal Government must "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement" of the environmental impact of such an action. Major Federal actions

"... includes actions with effects that may be major and which are potentially subject to Federal control and responsibility ... actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (Sections 1506.8, 1508.17) . . . . Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as federal and federally-assisted activities"(40 CFR 1500).

1.4.1.1 Federal Laws, Regulations, and Guides for Protection of Health and Environment

Table 1.8 provides an overview of federal laws and regulations for the protection of health or environment and the administering agencies. Federal agency responsibilities for water use, conservation laws, and exploration and mining rights are indicated in columns 1-4. Laws and regulations for environmental quality and health and safety are indicated in columns 5-10. See Appendix A for an itemized list of the laws and regulations shown generally in Table 1.8.

1.4.1.1.1 Air Quality

Regulations on air quality have been promulgated pursuant to the Clean Air Act (42 U.S.C. 1857 et seq), which includes the Clean Air Act of 1963 (Public Law 88-206) and amendments by the following: Public Law 89-272, Public Law 89-675, Public Law 90-148, Public Law 91-604, Public Law 92-157, Public Law 93-319, Public Law 95-95, and Public Law 95-190. The Environmental Protection Agency establishes National Ambient Air Quality Standards, New Source Performance Standards, and National Emissions Standards for Hazardous Air Pollutants under the Clean Air Act (CAA). Primary standards are set to protect public health and secondary standards are set to protect public welfare from known or anticipated adverse effects.

National Ambient Air Quality Standards (NAAQS) have been established for seven pollutants in 40 CRF 50. The Administrator of EPA is authorized to set emission standards for hazardous air pollutants for which no ambient air quality standard is applicable. Asbestos, beryllium, mercury, and vinyl

Table 1.8 Federal laws, regulations, and guides for uranium mining

| Federal Agency | General: Water Use | General: Conservation-Preservation Statutes | Permits: Exploration Rights | Permits: Mining Rights | Mining Environmental Quality: Air | Mining Environmental Quality: Water Surf | Mining Environmental Quality: Water UG | Mining Environmental Quality: Land Solids | Mining Environmental Quality: Land Reclam | Health and Safety |
|---|---|---|---|---|---|---|---|---|---|---|
| Dept. of Int. | X | X | X | X | | | | | X | |
| BIA[a] | | | X | X | | | | | X | |
| BLM[a] | | X | X | X | | | | | X | |
| USGS[a] | | | X | | | | | | X | |
| Dept. of Energy | | X | X | X | | | | | X | |
| Dept. of Agr. | X | X | | | | | | | X | |
| USFS[a] | | | X | X | | | | | X | |
| EPA | X | X | | | | X | | X | X | X |
| AIR-OAQPS[a] | | | | | X | | | | | |
| Water | | | | | | | | | | |
| Surface OWPS[a] | | | | | | X | | | | |
| Ground OSW[a] | | | | | | | X | | | |
| Land-OSW[a] | | | | | | X | X | X | X | |
| Radiation-ORP[a] | | | | | X | X | X | X | X | X |
| U.S. Army | | | | | | | | | | |
| Corps of Engrs. | X | X | | | | X | | | X | |
| Dept. of Labor | | X | | | | | | | | |
| MSHA[a] | | | | | | | | | | X |
| OSHA[a] | | | | | | | | | | X |
| Nuclear Reg. Comm.[b] | | X | | X | | X | | X | X | X |

(a) BIA-Bureau of Indian Affairs
BLM-Bureau of Land Management
USGS-United States Geological Survey
USFS-United States Forest Service
OAQPS-Office of Air Quality, Planning and Standards
OWPS-Office of Water Planning and Standards
OSW-Office of Solid Waste
ORP-Office of Radiation Programs
MSHA-Mining Safety and Health Administration
OSHA-Occupational Safety and Health Administration

(b) Nuclear Regulatory Commission (NRC) regulations and guides for milling do apply to in situ extraction or mining but not conventional surface or underground mining where NRC has no authority.

chloride emission standards are in subparts, B, C, E, and F of 40 CFR 61, respectively. Section 122 of the CAA directed the Administrator to determine whether emissions of radioactive pollutants, cadmium, arsenic, and polycyclic organic matter (such as benzene) into ambient air will cause or contribute to air pollution and endanger public health. If they do, EPA must propose emission standards for them within 180 days after that decision. The EPA has listed radionuclides as "hazardous pollutants" under Section 112 of the Clean Air Act in December 1979 (44FR76738, December 27, 1979). To date, no standards for radionuclide emissions in air have been promulgated.

The particulate concentration values of the NAAQS apply to mining operations. Emissions (including dust) must be controlled to meet the standards. Dust from mining operations was excluded from any air quality impact assessment for prevention of significant air quality deterioration (PSD) (see 43 F.R. 26395). However, as a result of the court decision in Alabama Power Company v. Costle, 13 ERC 1225, EPA has proposed amendment of PSD regulations (44 F.R. 51924, September 5, 1979).

The emission of radioactive substances or gases from gaseous release is controlled by NRC regulations 10 CFR Parts 20 and 40 for uranium milling and in situ leaching. The NRC does not have this authority over mining. There are no Federal regulations for radioactive pollution of air from mining at this time. However, MSHA enforces standards for radioactivity in air inside mines (30 CFR 57.5-37 through 57.5-42). Health and Safety standards of MSHA for Metal and Nonmetallic Mine Safety are given in 30 CFR Parts 55, 57, and 58.

1.4.1.1.2 <u>Water Quality</u>

Standards for water quality are promulgated by EPA under the Federal Water Pollution Control Act (FWPCA) of 1948 (as amended) and the Safe Drinking Water Act (SDWA) (as amended). The FWPCA and SDWA regulate surface water quality and groundwater quality, respectively.

The Federal Water Pollution Control Act Amendments of 1972(Public Law 92-500) established that no one has a right, without permit, to discharge pollutants into navigable waters of the nation. The Act provides for the establishment of both water quality standards and effluent limitations. In addition to requiring effluent standards for existing sources, it required EPA to set new source performance standards for uranium mining. The following standards and guidelines apply to uranium mining and milling: Regulations on Policies and Procedures for the National Pollutant Discharge Elimination System (40 CFR 125), Effluent Guidelines - Mining and Processing (40 CFR 116), Effluent Guidelines and Standards for Mining and Processing (40 CFR 436), and Protection of the Environment-Ore Mining and Dressing - Point Source Category (40 CFR Part 440). Table 1.12 lists other pertinent regulations and guides.

The Safe Drinking Water Act primarily protects municipal water systems. Part C of the Act requires that states establish underground waste water injection programs according to EPA regulations. Most mining operations dispose of waste water through surface discharges subject to the NPDES permit program and to the FWPCA. However, if a mine or mill seeks to dispose of polluted water by injection and such injection may endanger public drinking water supplies, then the Safe Drinking Water Act would apply. Finally, EPA will be developing regulations pursuant to Subtitle C of the Resource Conservation and Recovery Act that will provide controls on hazardous uranium mining wastes, including protection of groundwater resources. Section 4004 criteria, promulgated on September 13, 1979, apply to the nonhazardous portion of the wastes.

The NRC's water quality standards for radioactivity in discharges from uranium milling to the environment are in 10 CFR Parts 20 and 40. These would apply to in situ mining licensed by NRC or an agreement state.

1.4.1.1.3 <u>Land Quality</u>

Federal regulations on solid waste disposal and land reclamation specifically for uranium mining wastes are being developed pursuant to the Solid Waste Disposal Act (as amended). The Surface Mining Control and Reclamation Act of 1977 only applies to coal mining. Uranium mining occurs on Federal lands, where the Departments of Interior and Agriculture require reclamation. A large part of the western states is Federally owned land: Arizona (43 percent), California (45 percent), Colorado (36 percent), Idaho (64 percent), Montana (30 percent), Nevada (87 percent), New Mexico (34 percent), Texas (2 percent), Utah (66 percent), Washington (29 percent), and Wyoming (48 percent). State laws and local zoning ordinances may affect waste disposal. Many states authorize counties to regulate land use outside incorporated areas. Likewise, many states allow cities, towns, and villages to enact zoning ordinances for land use within their boundaries. Thus, mining operations in each state are subject to different reclamation requirements, depending upon land ownership and location.

Regulations for hazardous uranium mining wastes have been proposed by the EPA pursuant to Subtitle C of the Solid Waste Disposal Act as substantially amended by the Resources Conservation and Recovery Act of 1976 (Public Law 94-580). These were published in the Federal Register (43 F.R. 58946-59028) on December 18, 1978. Waste rock and overburden from uranium mining are listed as hazardous wastes, because they contain radioactive substances that meet the definition of hazardous wastes given in Section 1004 (5) of the Act. Special waste standards (Part 250.46-4) were proposed for the treatment, storage, and disposal of overburden and waste rock.

### 1.4.1.2 Federal Mineral Leasing and Location/Patent Laws

Some Federal regulations govern mineral exploration and mining rights. The Mining Law of 1872 (30 USC §§ 21-50) permits persons to enter public lands to discover, locate, and mine valuable minerals. The law has no provisions for facility siting, surface protection, or reclamation. Free use of water and timber for the mining operation and land for a mill site are ancillary rights granted by the law. Most subsequent mineral leasing laws are similar, designed to provide an orderly system for locating, removing, and utilizing valuable mineral deposits on federally owned and controlled lands. Pursuant to Section 603 (C) of the Federal Land Policy and Management Act of 1976, DOI has proposed specific environmental protection regulations (43 CFR 3800) for mining activities in potential or identified wilderness study areas (44 FR 2620).

1.4.1.2.1 Prospecting and Mining Rights

Consideration of environmental impacts may be required before obtaining the right to prospect or explore. Depending upon land category, prospectors may have to assess the environmental impact of mineral exploration before being permitted to explore. Table 1.9 summarizes these requirements. Prospectors on private lands simply must have permission from the owner of record of mineral estate. On the other hand, Tribal and Indian lands, National Forest System lands, and public lands (not public domain) all have specific approval systems that require exploration plans or other appropriate considerations.

Obtaining rights to mine usually involves the same Government agency involved with prospecting rights. Table 1.10 summarizes applicable Federal laws and regulations.

1.4.1.2.2 Mining and Environmental Plans

Before mining begins certain operating or mining and reclamation plans must be submitted and approved. Table 1.11 summarizes these. The requirements parallel those for prospecting and mining rights.

1.4.1.3 Laws Having Potential Applicability

Federal laws require regulation for quality of air, water, and land. In addition, though their direct influence has not been evaluated in this report, federal laws protecting wildlife and cultural resources could affect uranium mining activities.

Water use is also of potential concern in regard to uranium mining. However, except for in situ mining, uranium mining operations have modest needs for water. In fact, most mines typically dispose of significant quantities from necessary dewatering. Appendix B lists federal water programs and rights activities and the lead agencies administering them; and Appendix C lists Congressionally approved compacts that apportion water. These compacts apportion water to the affected states, and each state in turn allocates its share of the water among intrastate users on the basis of its own system of water rights.

Table 1.9 Requirements to obtain rights to prospect or explore by federal, state and private lands

| Land Category | Requirements |
|---|---|
| Federal: | |
| Tribal............ | Prospecting permit issued by BIA with consent of tribe. 25 CFR 171.27a. Technical examination of environmental effects of prospecting by BIA, 25 CFR 177.4. Exploration plan submitted to USGS. Approval of plan by USGS required, 25 CFR 177.6. Enforcement of plan by USGS, 25 CFR 177.10. |
| Allotted Indian.... | No specific provisions for prospecting. Procedure for leasing to prospect is same as for mining. If allotted land has been patented, treat same as private land. |
| Public Domain...... | No restriction on prospecting. Entry under General Mining Law of 1872 (30 USC 22, 43 USC 1744, 43 CFR Part 3810), uranium included, 43 CFR 37461. |
| Acquired Public.... | Prospecting permit from BLM, 43 CFR 3510.0-3 and 3511.2-1. Acquired lands not subject to prospecting permits are listed in 43 CFR 3501.2-1. If acquired land is not under BLM jurisdiction, consent of governmental entity having jurisdiction is required before permit issued by BLM (43 CFR 3501.2-6). |
| Withdrawn Public... | Public domain land withdrawn for power development is open to entry and location under General Mining Law of 1872, 30 USC 621. Agency having control of withdrawn land reports any objections to mining activity based on land use for which withdrawal was made. If controlling agency recommends stipulations in the permit, they are included (43 CFR 3501.3-1 (a), (c). |
| Reserved Public.... | Some Federal lands are disposed of with minerals reserved to the Government; e.g., see 43 USC 299, 43 CFR 3814.1, 30 USC 50. For these lands, permit issued by BLM requires conformance with law under which reservation was made, 43 CFR 35013-2(2). For lands reserved or segregated for particular purpose, special requirements may be made by BLM for protection and use of land for purpose that it was reserved or segregated. Leases from Dept. of Energy may be possible under 42 USC 2097. |

Table 1.9 (Continued)

| Land Category | Requirements |
| --- | --- |
| National Forest System... | Public domain lands inside National Forest System boundaries are subject to General Mining Law of 1872, with the following conditions: (a) If Dept. of Agriculture requires operations plan, it must be submitted. Dept. of Agriculture approves plan, 36 CFR 252.1; (b) Operations must minimize environmental impact on surface resources in System lands, 36 CFR 252.8; (c) Surface inspection and securing compliance with plan is responsibility of Dept. of Agriculture, 36 CFR 252.7. Acquired National Forest System land same as Acquired Public Land. |
| State.................. | Lease obtained from appropriate State Agency according to state law. |
| Private................ | Permission given by owner of record of mineral estate. |

Source: San Juan Basin Regional Uranium Study, Working Paper No. 28, Legal Infrastructure Related to *Uranium Mining in the San Juan Basin*, United States Department of Interior.

Table 1.10 Requirements to obtain rights to mine ore by federal, state, and private lands

| Land Category | Requirements |
|---|---|
| Federal: | |
| Tribal | Secretary of Interior has general authority for leases, 25 USC 396a. Tribe must approve. Leases given by bid. Approval of Secretary of Interior required, 25 CFR 171.2. Tribe may negotiate lease if Secretary grants permission. Secretary has discretion to reject lease negotiated by Tribe, 25 CFR 171.2. Secretary may issue charter of incorporation to Tribe which may include authority for Tribe to negotiate mining leases without approval. |
| Allotted Indian | Leases given by bid. If Secretary of Interior approves, leases may be negotiated by Indian owners, but negotiated lease subject to rejection by Secretary, 25 CFR 172.4 and 172.6. Approval of allottee required. If patented, treat same as private land. |
| Public Domain | No lease required. Location of mineral deposit (staking a claim) after mineral has been discovered, 43 CFR 3831.1 and 3841.3. File locations with BLM and in accordance with 43 USC 1744. Also record in accordance with State law. Obtain patent for land claimed, 30 USC 29, 43 CFR Part 3860. Mill sites may be claimed by location and patenting, 30 USC 42, 43 CFR Subpart 3844. If claim has been patented, treat same as private land. |
| Acquired Public | Mineral estate on acquired lands can be leased by BLM, 43 CFR 3501.3-1, subject to exceptions (43 CFR 3501.1-5 and 3501.2-1). Permittee who prospected and discovered is entitled to preference right lease, 43 CFR 3520.1-1(a)(3). BLM leases land which contains valuable minerals on competitive basis, 43 CFR 3520.1-2(a). If land is not under BLM jurisdiction, consent of governmental entity having jurisdiction is required before lease issues. |
| Withdrawn Public | For public domain land withdrawn for power development, laws are same as for land in Public Domain, 30 USC 621. If withdrawal does not preclude mining, BLM can lease mineral estate. Agency having jurisdiction of withdrawn land reports any objections to mining activity, based on land use for which withdrawal was made. If controlling agency recommends stipulations in lease, they are included, 43 CFR 3501.3-1(a)(c). Leases from Dept. of Energy on lands withdrawn for DOE use under 42 USC 2097. |

Table 1.10 (Continued)

| | Land Category | Requirements |
|---|---|---|
| 6. | Reserved Public | Some Federal lands are disposed of with minerals reserved to the government; see e.g. 43 USC 299, 43 CFR 3814.1 and 30 USC 50. For these lands, lease issued by BLM requires conformance with law under which reservation was made, 43 CFR 3501. 3-2(2). For lands reserved or segregated for particular purpose, special requirements may be made by BLM for protection and use of land for purpose that it was reserved or segregated. |
| 7. | National Forest System | Public Domain land inside National Forest System boundaries are subject to General Mining Law of 1872, with the following exceptions: 36 CFR 252.1, (a) If Department of Agriculture requires operations plan, it must be submitted. Department of Agriculture approves plan; (b) Operations must minimize environmental impact on surface resources on System Lands, 36 CFR 252.8; (c) Surface reclamation required, 36 CFR 252.8(g); (d) Inspection and compliance with plan responsibility of Department of Agriculture, 36 CFR 252.7. Acquired National Forest System Land same as Acquired Public Land. |
| 8. | State | Leases obtained from appropriate State Agency according to state law. |
| 9. | Private | Lease of mineral estate (or total estate) by private negotiation. |

Source: San Juan Basin Regional Uranium Study, Working Paper No. 28, Legal Infrastructure Related to Uranium Mining in the San Juan Basin, United States Department of Interior.

Table 1.11 Requirements for mining and environmental plans by federal, state, and private lands

| Land Category | Requirements |
|---|---|
| Federal: | |
| Tribal | Mining plan must be approved by USGS. If lease requires revegetation, the revegetation work is included in mining plan. Mining plan can be changed by mutual consent of USGS and operator, 25 CFR 177.6. BIA evaluates environmental effect of proposed operations and formulates environmental mitigation requirements. BIA consults with USGS, 25 CFR 177.4. |
| Allotted Indian | Same as Tribal Land, 25 CFR 177.1., unless allotted land has been patented. If patented, treat same as private land. |
| Public Domain | Plan same as acquired public land. |
| Acquired Public | Geological survey approval of mining plan to mitigate adverse environmental effects for federal leases, 30 CFR 231.10. |
| Withdrawn Public | Stipulations can be put in the lease by the agency for whom the land was withdrawn. These could affect operations but no formal submission of plans required, 30 CFR 231.10. |
| Reserved Public | Lessee must conduct operations in conformance with such requirements as may be made by BLM. Requirements will conform to purposes for which land was reserved, 43 CFR 350.3-2(b). Approval of mining plan required, 30 CFR 231.10. |
| National Forest System | Operations plan submitted to District Ranger, Department of Agricultural, if he deems it necessary, 36 CFR 252.4. Reclamation of surface required under opertor's plan, 36 CFR 252.8(g). Compliance with Federal and State environmental laws, preserve scenic values, wildlife, etc., 36 CFR 252.8. District Ranger, Department of Agriculture, inspects and assures compliance with operations plan, 36 CFR 252.7. |
| State | Mine plan filed with and approved by State. |
| Private | Same as State Land. |

Note.--Some states require submission of mining and reclamation plans for all land.

Source: San Juan Basin Regional Uranium Study, Working Paper No. 28, Legal Infrastructure Related to Uranium Mining in the San Juan Basin, United States Department of Interior.

### 1.4.2. State Regulations

Federal statutes and regulations control many areas of environmental quality. Most state licensing or regulatory authority is often the result of a Federal-State agreement. However, land reclamation for uranium mining on federal and nonfederal lands is principally under state control. Table 1.12 shows the regulatory scheme for six states with uranium mining, and Appendix D lists the specific laws, regulations, and guides indicated generally in Table 1.12.

Agreement states have made formal arrangements with the NRC to develop programs to issue by-product, source material, and processing licenses. The Atomic Energy Act (Sec. 274), as amended, requires agreement states to provide by 1981 regulatory programs that are equivalent to or more stringent than the federal requirements for mill operations. Much of the environmental regulation of mining operations outside of federally controlled lands, especially for reclamation activities, currently depends upon state or local requirements. No NRC licenses are required for mining, except in situ.

The Federal Water Pollution Control Act amendments of 1972 give EPA National Pollution Discharge Elimination System (NPDES) permitting authority. However, Section 402 provides for approval of a state or interstate program to permit. The Administrator has established guidelines specifying procedural and other elements that must be present to obtain approval (40 CFR 124). Where states have not been approved, applicants apply for discharge permits from EPA. However, EPA asks what state requirements should also be certified so that state standards are met. Column 2 of Table 1.12 lists states that are approved to issue NPDES permits.

The Clean Air Act (CAA) amendments of 1970 and 1977 require, under Section 110, that State Implementation Plans (SIP's) must be submitted for approval to EPA for implementation of CAA on a local level. The approval and implementation of State plans are given in 40 CFR 52. In areas where NAAQS are violated, SIP's must produce compliance by 1982. If a state fails to enforce its plan, EPA may enforce it. There are currently no emission standard regulations specific for uranium mining by State governments.

Table 1.12 State laws, regulations, and guides for uranium mining

| State | General: NRC Agreement State | General: NPDES Permit State | Mining: Water Use | Mining: Permits: Exploration Rights | Mining: Permits: Mining Rights | Mining: Environmental Quality: Air | Mining: Environmental Quality: Water: Surf | Mining: Environmental Quality: Water: UG | Mining: Environmental Quality: Land: Solids | Mining: Environmental Quality: Land: Reclam | Mining: Health and Safety |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COLORADO | Yes | Yes | - | - | - | - | - | - | - | - | - |
| Department of Health | | | | | | | | | | | |
| Water Quality Control Div. | - | - | - | - | - | | x | x | - | - | - |
| Air Quality Control Div. | - | - | - | - | - | x | - | - | - | - | - |
| Department of Natural Resources | | | | | | | | | | | |
| Div. of Water Reserves (State | - | - | x | - | - | - | - | - | - | - | - |
| Board of Land Commissioners | - | - | - | x | x | - | - | - | - | x | - |
| Mined Land Reclam Bd | - | - | - | x | x | - | x | x | - | x | - |
| Division of Mines | - | - | - | - | - | - | - | - | - | - | x |
| NEW MEXICO | Yes | No | - | - | - | - | - | - | - | - | - |
| State Land Commission | - | - | - | x | x | - | - | - | - | - | - |
| Dept. of Energy and Minerals | - | - | - | - | - | - | - | - | - | x | x |
| Dept. of Natural Resources | - | - | x | - | - | - | - | - | - | - | - |
| Env. Improvement Div. | - | - | - | - | - | x | x | x | x | - | x |
| TEXAS | Yes | No | - | - | - | - | - | - | - | - | - |
| Dept. of Water Resources | - | - | x | - | x | - | x | - | x | x | - |
| R.R. Commission of Texas | - | - | - | x | x | x | x | x | - | x | - |
| General Land Office | - | - | - | x | x | - | - | - | - | x | - |
| Dept. of Health | - | - | - | - | - | - | x | - | - | - | x |
| Air Control Board | - | - | - | - | - | x | - | - | - | - | - |
| UTAH | No | No | - | - | - | - | - | - | - | - | - |
| State Engineer | - | - | x | - | - | - | - | - | - | - | - |
| Dept. of Social Services | - | - | - | - | - | - | - | - | - | - | - |
| Division of Health | - | - | - | - | - | x | x | x | - | - | x |
| Water Pollution Control Bd. | - | - | - | - | - | - | x | x | - | - | - |
| Dept. of Natural Resources | - | - | - | x | x | - | - | - | - | x | - |

Table 1.12 (continued)

| State | GENERAL: NRC Agreement State | GENERAL: NPDES Permit State | Mining: Permits: Water Use | Mining: Permits: Exploration Rights | Mining: Permits: Mining Rights | Mining: Permits: Air | Mining: Environmental Quality: Water: Surf | Mining: Environmental Quality: Water: UG | Mining: Environmental Quality: Land: Solids | Mining: Environmental Quality: Land: Reclam | Mining: Health and Safety |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WASHINGTON | Yes | Yes | - | - | - | - | - | - | - | - | - |
| Dept. of Natural Resources | - | - | - | x | x | - | - | - | x | x | - |
| Dept. of Ecology | - | - | x | - | - | - | - | - | - | - | - |
| Office of Water Programs | - | - | - | - | - | - | x | (No) | - | - | - |
| Dept of Social Services & Health | - | - | - | - | - | - | - | - | - | - | - |
| Health Services Division | - | - | - | - | - | - | - | - | - | - | x |
| Air Quality Division | - | - | - | - | - | x | - | - | - | - | - |
| WYOMING | No | Yes | - | - | - | - | - | - | - | - | - |
| State Inspector of Mines | - | - | - | x | x | - | - | - | - | x | x |
| State Engineers Office | - | - | x | - | - | - | - | - | - | - | - |
| Dept. of Env. Quality | - | - | - | - | - | - | - | - | - | - | - |
| Air Quality Div. | - | - | - | - | - | x | - | - | - | - | - |
| Water Quality Div. | - | - | - | - | - | - | x | x | - | - | - |
| Land Quality Div. | - | - | - | x | x | - | - | - | x | x | - |
| Solid Waste Management | - | - | - | - | - | - | - | - | x | - | - |

Note.--An "x" indicates the existence of one or more controlling laws, regulations, or guides. See Appendix D for a list of the specific laws, regulations, or guides.

Applicable laws, regulations, and guidelines that apply to uranium mining in Colorado, New Mexico, Texas, Utah, Washington, and Wyoming are discussed below. Laws and regulations of other previously mined or potential uranium mining states, such as Arizona, California, Idaho, Montana, and South Dakota, are not reviewed. However, the basic environmental considerations of uranium mining should not be significantly different for other states.

### 1.4.2.1. Colorado

Colorado is an NRC "Agreement State" and has been approved by the EPA to issue NPDES discharge permits. Both radiation and water quality regulatory activities are under the jurisdiction of the Colorado Department of Health. The Health Department's Radiation and Hazardous Wastes Control Division administers radiation control activities and the control of hazardous wastes disposal. However, there are no operable rules or regulations for mining. Water quality is the responsibility of the Water Quality Control Commission (affiliated with the Health Department), which promulgates water quality standards and control regulations, and the Health Department's Water Quality Control Division, which administers and enforces the Commission's regulations and issues NPDES permits, as well as being responsible for numerous other water quality activities.

Colorado's permitting of discharges to "navigable" waters has been approved by EPA. Unlike most states, Colorado has promulgated specific "Guidelines for Control of Water Pollution from Mine Drainage" (November 10, 1970). These guidelines have the status of regulation since the State does not issue the NPDES permit unless the guidelines will be met. Colorado also has "Rules for Subsurface Disposal Systems" that, in conjunction with other rules, may assure protection of groundwater. These "Rules" cover all wastes that are disposed of underground, whether by direct or indirect means. "Wastes" include "any substance, solid, liquid, or gaseous, including radioactive particles thereof, which pollute or may tend to pollute any waters of the State." Solid waste and other land disposals are covered by Section 25-8-501, CRS 1973, as amended. In cases where these regulations do not control, the rules for subsurface disposal systems may apply.

The Colorado Department of Natural Resources administers water use in Colorado. As with most Western States, water is not in great abundance in Colorado. Determination of priority of water rights to surface and tributary groundwater is under the jurisdiction of a system of Water Courts, while the Division of Water Resources (State Engineer) administers and controls the allocation of actually available waters on an annual basis according to water rights priorities.

There are no State air quality standards or regulations that apply specifically to uranium mining. However, the National Ambient Air Quality Standards and various State emission control regulations apply to uranium mining activities as they do to all other types of emission sources. Colorado's air quality activities are the responsibility of the State Health Department's affiliated Air Quality Control Commission and its Air Quality Control Division. The Commission defines State air quality policy and promulgates air quality ambient standards and emission control regulations, while the Division administers and enforces the air quality regulations and issues emission permits.

The Board of Land Commissioners, affiliated with the Colorado Department of Natural Resources, issues permits for prospecting and controls leases for mining on State lands. The Board has policies and regulations concerning environmental impacts on prospected or leased lands.

The Colorado Mined Land Reclamation Board was created in 1976. It is adminstered by the Department of Natural Resources. The Board issues permits for all mining operations on all Federal and non-Federal lands in the State. The stated intent for Colorado Mined Land Reclamation Law is "to allow for the continued development of the mining industry in this State, while requiring those persons involved in mining operations to reclaim land affected by such operations so that the affected land may be put to a use beneficial to the people of this State. It is the further intent...to conserve natural resources, aid in the protection of wildlife and aquatic resources, and establish agricultural, recreational, residential, and industrial sites and to protect and promote the health, safety, and general welfare of the people...." The Board has established rules and regulations to implement the law. Rule 5 (Prospecting Notice and Reclamation Requirements) considers prospecting a separate activity, but still covered by certain reclamation requirements. The reclamation performance standards of Rule 6 have specific requirements for grading, hydrology and water quality, wildlife safety and protection, topsoiling, and revegetation. Rule 7 ("Surety") assures reclamation. Before the Board issues any permit and before any Notice of Intent to Prospect is valid, the applicant must post surety with the Board. The amount of surety, established by the Board, is to be sufficient to fully reimburse the State for all expenses it would incur in completing the reclamation plan in the event of default by the operator.

Colorado also has regulations that apply for health and safety in mining operations. For each invidual employee of any mining operation within the state a lifetime history is maintained on exposure to radon daughter concentrations when certain minimum values are reached. The State Department of Natural Resources Division of Mines administers these.

#### 1.4.2.2 New Mexico

In New Mexico, a mine plan must be filed with and approved by the State Mining Inspector before he will issue a permit. The State Mining Inspector does not review the plan for environmental impact. Groundwater use rights are established by the State Engineer, and the Land Commission handles exploration and mining rights. The engineer's office issues a permit for beneficial use of any water pumped from uranium mines. However, the Navajo tribe claims jurisdiction of the State's groundwater in the northwest region of New Mexico. It is likely that the Departments of Interior and Justice will eventually become involved in this dispute as Trustees for the tribe.

Approval status has been given, with some exceptions, by EPA to New Mexico's plan for the attainment and maintenance of national air standards (40 CFR 52.1622). However, neither Federal nor State regulations include specific emission standards for uranium mining. But "Ambient Air Quality Standards" (40 CFR 50.6) on suspended particulates apply to all sources of air pollution.

New Mexico is an NRC agreement state, but it is not an approved NPDES state. Part 2 of the amended Water Quality Control Commission regulations applies to any discharge that is not subject to a permit under the NPDES system. The State requires approved discharge plans for discharges that could contaminate groundwater. However, the applicable NPDES regulations (Subpart E-Uranium, Radium and Vanadium Ores Subcategory, 40 CFR 440.50) have been challenged by some mine operators. They claim that discharges to a dry arroyo do not constitute "the discharge of pollutants into the navigable water, water of the continguous zone, and the oceans." Because more than half of active New Mexico mine discharges have NPDES permits that are now under adjudication, there is no enforcement and discharges may not be in accordance with Standards. If the NPDES challenge is sustained, then New Mexico's Part 2 regulations could be applied, even though they are not particularly suitable for uranium mining discharges. Possibly only the regulations on chemical oxygen demand and settling of heavy metal solids would apply to uranium mine wastes. The Part 3 "Regulations for Discharges onto or below the Surface of the Ground" (3-100) that are designed to "protect all groundwater" would also be important. A discharge plan is required for effluent discharges that move directly or indirectly into groundwater, if the effluent contains any of the contaminants listed in Section 3-103 a, b, and c, or toxic pollutants. Since the list of contaminants includes uranium and radium, New Mexico can approve only discharge plans meeting the drinking water standards.

There are no state regulations for solid wastes and land reclamation for mining operations. The mining plan and bonding requirements associated with mining permits determine the extent of mining reclamation.

Radiation safety requirements (Sections 74-3-1 et seq NMSA 1978) apply to both mining and milling. Air quality monitoring in underground mines currently involves potential duplication of effort by the New Mexico Mine Inspector (69-5-7 et seq NMSA 1978) and the Federal Mine Safety and Health Administration (30 CFR 57.5-37).

### 1.4.2.3 Texas

Texas is an NRC agreement state, but not an EPA approved NPDES permit state. The Department of Water Resources controls water use. Even though much of the water used in Texas comes from wells, there are no regulations on pumping groundwater. However, some counties have regulations that limit groundwater withdrawal to control subsidence.

Specific regulations for in situ uranium mining are enforced by the Texas Department of Health (TDH). Since Texas is an agreement state, its regulations reflect all appropriate NRC regulations. The TDH also implements the Safe Drinking Water Act (SDWA) and monitors groundwater to assure that its provisions for radium and selenium concentrations are met.

The General Land Office (GLO) issues prospecting permits and mining leases on state-owned lands. Mining and reclamation plans for uranium mining on state-owned lands are reviewed for approval by GLO. The "Texas Uranium Surface Mining and Reclamation Act" exempts state-owned lands from regulation by the Railroad Commission.

Surface mining is regulated by the Railroad Commission. All requirements of state and federal laws must be fulfilled before a permit is issued. Mining and reclamation plans must be submitted and approved. A bond is required to assure reclamation after mining.

The Texas Air Control Board administers provisions of the Clean Air Act. Except for suspended particulates, there are no applicable standards, i.e., there are no state source standards, for uranium mining.

The Texas Guides and Regulations for Control of Radiation (TRCR) do not apply to surface uranium mining. They do apply to in situ mining due to NRC agreement state licensing. The radioactive content of water discharged from all mines to the environment must not exceed TRCR limits.

### 1.4.2.4 Utah

Utah is neither an NRC agreement state nor an NPDES permit approved state. The Utah State Engineer's Office is responsible for approval of water use rights. The Department of Natural Resources oversees exploration and mining rights on State lands.

The Division of Oil, Gas, and Mining of the Department of Natural Resources issues permits for uranium mining operations, except in situ mining licensed by the NRC. A mining and reclamation plan must be approved. Rule M-10 standards include consideration of land use, public safety and welfare, impoundment, slopes, high walls, toxic materials, roads and pads, draining, structures and equipment, shafts and portals, sediment control, revegetation, dams, and soils. Bonding requirements assure reclamation.

Discharges to surface waters are regulated under the EPA administered NPDES system and the Utah Water Pollution Committee. Utah does have separate regulations administered by the Department of Social Services. These are applied to mining operations such as non-discharging waste water systems and in situ mining where no NPDES permit is required.

No sources of pollution will be allowed to cause groundwaters to exceed drinking water standards. The applicable standards for classes 1A and 1B domestic water sources are given in Wastewater Disposal Regulations, Part II.

Utah is developing radiation safety regulations. We do not expect that they will apply to uranium mining, since they are based on the model state suggested regulations.

1.4.2.5 Washington

Washington is an NRC agreement state and an NPDES approved permit state. The Department of Ecology regulates water use and water quality. Washington has no regulations for groundwater. These waters could be protected under the Safe Drinking Water Act.

The Department of Natural Resources controls exploration and mining rights for state-owned lands only. The mineral lease law covers both surface and underground mining but not in situ or heap leaching. The State Reclamation Act applies to state and private lands only. A mining and reclamation bond is required before a permit is issued. Reclamation is assured through bonding requirements.

Washington has a Clean Air Act under which regulations have been promulgated consistent with the Federal Clean Air Act. No source emission standards have been issued for uranium mining. National Ambient Air Quality Standards could apply to suspended particulates.

Washington has rules and regulations for radiation protection, but they do not apply to uranium mining.

1.4.2.6 Wyoming

Wyoming is an approved NPDES permitting State but not an NRC Agreement State. The State Engineer's Office controls water use rights. Control is primarily on the quantity of water used, but there is some statutory responsibility regarding sedimentation. Discharges to surface waters are regulated by the Water Quality Division of the Department of Environmental Quality. The construction of any water or waste water facility requires a construction permit. Groundwater regulations have been proposed. These include groundwater quality standards for any activity. Permitting requirements specific to in situ uranium operations is one of a group of special process discharges.

The Land Quality Division of the Wyoming Department of Environmental Quality is the principle agency responsible for enforcing environmental protection standards and reclamation standards with respect to uranium mining operations. The Division also enforces mineral exploration regulations that afford protection to groundwater and restoration of significant surface disturbances.

Wyoming law requires that uranium mined land must be restored to a use at least equal to its highest previous use (W.S. 35-11-402(a)(i) and (ii)) and mining operations must be conducted to prevent pollution of waters of the State (W.S. 35-11-402(a)(vi)). Before a mining operation receives a permit it must submit to the Department a mining and reclamation plan that demonstrates compliance with the law and associated rules and regulations. The plan must contain a plan for the disposal of all acid-forming, toxic materials or materials constituting a fire, health, or safety hazard uncovered or created by the mining process: radioactive material is included (W.S. 35-11-406(b)(ix)).

An operator must also, in accord with his approved mine and reclamation plan, cover, bury, impound, contain, or dispose of toxic, acid-forming, or radioactive material determined to be hazardous to health and safety or constitute a threat of pollution to surface or subsurface waters (W.S. 35-11-415(b)(iv)). A required surety bond assures that the operator will reclaim the land according to his approved plan. If the bond is forfeited, the State is responsible for reclamation.

Wyoming has legislated authority for a position on radiological restoration of mined lands. It is described in the Division's Guideline No. 1, Section III. The Division is presently drafting regulations for radiation protection on uranium mined lands and handling of uranium mine wastes. These regulations shall set standards.

Wyoming also has a solid waste management program that presently regulates only refuse generated at mines. Solid waste disposal sites are permitted at these facilities. Solid waste regulations could be promulgated that affect mining.

In Wyoming, Ambient Air Quality Standards are applied to mining operations, and fugitive emissions are controlled to the extent that these standards are met. An Air Quality Permit is required for the construction of a uranium mining and/or processing facility, and the applicant is required to demonstrate that applicable ambient and PSD (Prevention of Significant Deterioration) provisions are met.

Wyoming has radiation protection regulations for the safety of mines while they are actually in process. These regulations are under the jurisdiction of the State Inspector of Mines. According to Wyoming Law, the protection of miners from hazardous exposure to radioactivity must conform to the American Standards Association revised Publication N 13.8, "Radiation Protection in Uranium Mines and Mills." The uranium regulations (94-R-11) are found in Chapter 3, Article 4 of Title 30 - Mines and Minerals.

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